RECOGNIZING DUST EXPLOSION HAZARDS IN INDUSTRIAL PLANTS

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Introduction

The Bureau of Agricultural Chemistry and Engineering, which I have the honor to represent at this meeting, is engaged in scientific research studies relating to chemical and engineering problems connected with explosions and fires in the handling, milling, processing, and storage of agricultural products. In this research work on explosion and fire prevention our Bureau has cooperated very closely with the agricultural industries directly concerned and with the fire departments in the handling of fire-fighting operations in connection with these industrial plants. A very pleasant and helpful relationship has been established with these industries, fire departments, and fire prevention associations, safety and insurance organizations, and State and Federal agencies. Among the national organizations cooperating in this explosion and fire prevention work are the National Fire Protection Association, National Safety Council, International Association of Fire Chiefs, International Association of Fire Fighters, National Board of Fire Underwriters, National Fire Waste Council, Western Actuarial Bureau, American Standards Association, and a number of other national organizations interested in the fire and explosion prevention movement.

This direct contact with these organizations affords a ready means of translating into actual practical use the results of technical research on dust explosion prevention, and it is therefore especially pleasing to have an opportunity to present some of the developments in this research work.

(I) Research Work on Dust Explosion Prevention

It should be entirely unnecessary to inform a Pittsburgh audience that the Federal Government has conducted extensive research studies to determine the causes of dust explosions and to develop methods for their prevention and control.

The Bureau of Mines, U. S. Department of the Interior, with its finely equipped testing station in this city, has definitely established the fact that explosions can occur in bituminous coal mines without the presence of explosive mine gases, and that the ignition of the coal dust itself has been responsible for many disastrous mine explosions. As a direct result of effective research work by that Bureau methods have been developed for the use of inert dusts, such as shale, limestone, and gypsum, for the control and prevention of coal dust explosions. Reports issued by the Safety Section of the Bureau of Mines indicate that these methods have proved very satisfactory.

The studies of the Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, show that under favorable conditions a dust explosion can occur in any industrial plant or manufacturing establishment where combustible dust is created during manufacturing operations.

When these research studies were undertaken it was generally supposed that it would be necessary to grind or crush grain and produce the powdery, starchy materials from the inside of the grain before an explosive dust would be encountered. This was largely due to the fact that an explosion of flour dust produced in the manufacture of wheat flour in a Minneapolis mill in 1878 caused the loss of 18 lives and extensive property damage. A large number of explosions in grain elevators, where no grinding or manufacturing operations were engaged in, showed definitely that the dust produced in the handling, elevating, conveying, and storing of grain also was explosive.

A survey has shown that the dust explosion hazard exists in a wide range of industries, such as flour and feed mills, grain elevators (both terminal and rural), starch factories, sugar refineries, woodworking plants, powdered milk plants, soap powder factories, sulphur crushing and pulverizing, hard rubber recovery plants, cork pulverizing plants, chocolate and cocoa plants, paper mills, insecticide plants, celluloid and textile plants, aluminum, zinc, and magnesium plants, fertilizer plants, and rosin-handling plants.

We find, therefore, that approximately 28,000 industrial plants in the United States are subject to the dust explosion hazard. These plants normally employ 1,325,000 persons and manufacture products having an annual value of more than ten billions of dollars ($10,000,000,000).

NEED FOR CONTINUED SAFETY EDUCATION

Research studies on the prevention of dust explosions in industrial plants have been going on for several years. During the World War period, when grain dust explosions threatened to have a serious effect in reducing available food supplies, an intensive educational campaign was conducted throughout the United States in grain elevators, flour mills, and processing plants where a dust explosion hazard was present.

After all this activity, it would appear reasonable to expect that the officials and employees in industrial plants where explosive dusts are produced would be fully informed as to the hazards of dust explosions and the methods that should be employed for their prevention or control. However, the investigation of some recent explosions has definitely indicated that many of the younger employees in a number of industrial plants have not had occasion to become familiar with the dust explosion hazard, and that the educational work carried on twenty years ago must be resumed with the oncoming generation.

Fire protection and explosion prevention, while technical in many of their aspects, rest fundamentally upon public education; it is only when these subjects are understood that the necessary impetus is given for the application of technical measures of fire prevention and fire protection. It is very important to remember that public education, or even education of a limited group, must be continuous to be effective. For instance, a given group of employees in some recognized hazardous

industry may be fully informed as to the importance of fire and explosion safety measures, with resultant notable decrease in fire and explosion losses; but as a new generation comes into the industry educational activities must be continued in order to maintain the improved record. A striking example of this is furnished in the field of dust explosion prevention.

SOME COMPARISONS

A comparison of two explosions in different lines of industry may serve to indicate the importance and value of continued safety education.

(a) Explosion in Boiler Room - Brewing Plant

An explosion in the boiler room of a brewing plant resulted in the death of five persons, injuries to several others, and extensive damage to the building and equipment. This explosion occurred during the elevating of coal tar pitch, used for fuel, from a delivery truck on the street level to the top of the storage bunker on approximately the fourth floor of the building. The use of electric welding equipment during repair work on the steel elevator leg casing while the equipment was running was considered responsible for the ignition of the pitch dust cloud produced in connection with the unloading, elevating, and storage operations. The investigation of this explosion disclosed that, although the operating official had been in charge of the boiler plant for approximately fourteen years, he was not adequately informed on the dust explosion hazard. This explosion showed definitely that repair operations of any kind in plants where explosive dusts are produced should not be carried on while equipment and apparatus are in operation.

(b) Explosion in Starch Factory

In contrast with the explosion just cited, it is of particular interest to consider an explosion which occurred in a starch factory a few months before. No employees were either burned or injured and the property loss was less than $500, chiefly because the management and employees were familiar with the dust explosion hazard and had applied proper safety measures for the prevention of dust explosions in starch factories.

The fact that there was no loss of life in this explosion, no employees injured, and the property loss was very small is particularly significant when it is recalled that a previous explosion in this same plant several years before caused the loss of 42 lives, injuries to many others, and property damage of about $750,000. The earlier explosion, of course, occurred prior to the development of the safety code for the prevention of dust explosions in starch factories.

The limited effects of the explosion in this starch plant indicate definitely the splendid work which has been done in the prevention of dust explosions. No life has been lost from a dust explosion in the starch and corn products industries since September, 1930 - a period of almost nine and a half years. This remarkable record is a significant indication of the value of the work of the safety organizations in the

EXTENT OF DUST EXPLOSION LOSSES

In the last 20 years - the period from 1919 to 1938 - there have been 398 dust explosions in industrial plants in the United States. In those explosions 318 persons lost their lives and 712 others were injured. The property and stock losses (insurance paid) amounted to $28,302,685.

REDUCTION IN LOSSES

It is very gratifying to observe that there has been a marked reduction in losses from dust explosions in industrial plants in recent years. The comparative losses for the last two ten-year periods are as follows:

Losses for 10-year period, 1919 to 1928, incl.	$18,249,900
Losses for 10-year period, 1929 to 1938, incl.	10,052,785
Reduction in losses for 10-year period	$ 8,197,115
Average annual reduction in losses, approx.	$ 820,000

These reductions in dust explosion and fire losses as well as the savings in insurance costs which have ensued due to a reduction in rates for the application of dust-explosion and fire-prevention methods definitely show the economic value of this research work.

DEVELOPMENT OF SAFETY CODES FOR DUST EXPLOSION PREVENTION

The reduction in dust explosion losses has been due largely to the adoption of the measures recommended in the safety codes which have been developed by the Dust Explosion Hazards Committee of the National Fire Protection Association. This committee, composed of representatives from the various industries directly concerned and from insurance and safety organizations, State and Federal officials, and construction and equipment engineers, works under the leadership of the Chemical Engineering Research Division of the Bureau of Agricultural Chemistry and Engineering.

The following safety codes developed by the Dust Explosion Hazards Committee have been adopted by the National Fire Protection Association and the National Board of Fire Underwriters, and approved as "American Standards" by the American Standards Association.

1. Flour and feed mills
2. Sugar and cocoa pulverizing
3. Pulverized fuel installations
4. Terminal grain elevators
5. Starch factories
6. Coal pneumatic cleaning plants
7. Wood flour manufacturing establishments
8. Spice-grinding plants
9. Wood-working plants
10. Use of inert gas for fire and explosion prevention
11. Aluminum-bronze powder manufacturing plants.

A safety code for the prevention of dust explosions in the handling, grinding, and storing of sulphur has been recently prepared by this committee as well as an outline of Fundamental Principles for the Prevention of Dust Explosions in Industrial Plants, not covered by special codes. These complete codes have been recently made available by the National Fire Protection Association in a publication entitled, "National Fire Codes for the Prevention of Dust Explosions."

SAFETY CODE FOR ALUMINUM BRONZE POWDER MANUFACTURE

The preparation of the new safety code for the Prevention of Dust Explosions in the Manufacture of Aluminum Bronze Powder which has been recently approved as "American Standard," is a splendid example of the fine spirit of cooperation on the part of the representatives of the industry in the preparation of this safety code. In their desire to provide the maximum safety possible in order to guard against the dust explosion hazard, these representatives wrote into this code recommendations covering the installation of electrical equipment which went beyond the requirements of the existing electrical code. The National Electrical Code has since been amended to include these suggestions. It is this spirit of cooperation on the part of industry which has made possible a marked reduction in our dust explosion losses.

The aluminum code is of special importance at this time because it represents the first work of the committee dealing with non-carbonaceous dust. It will be recalled that aluminum, a metal, was not considered a combustible material, or at least did not fit in the original definition which explained that any combustible material fine enough and dry enough to form a cloud in air could be ignited and would explode with violence under favorable conditions.

Laboratory tests had shown that aluminum powder could be ignited and would explode with violence. Actual explosions in aluminum plants, particularly the aluminum-bronze producing sections, had proved that a serious hazard to life and property existed in such plants unless protective measures were adopted. With the help and advice of representatives of the aluminum-bronze producing industry serving on a subcommittee under the direction of Dr. George S. Rice, formerly chief mining engineer of the U. S. Bureau of Mines, a safety code was prepared. After more than two years' consideration it was presented in May, 1939, to the National Fire Protection Association for adoption.

The new code follows the general pattern of the other dust explosion prevention codes, but makes specific recommendations concerning the location and construction of buildings, the making and handling of the powder, the location of electrical equipment, the elimination of sources of ignition, and fire-fighting methods.

GRAIN ELEVATOR LOSSES

Although losses from dust explosions have been reduced materially in the food-manufacturing industries which have cooperated in working out

and adopting practical safety and preventive measures against dust explosions and resulting fires, there is still need for more definite attention to the development and application of methods for the control and prevention of dust explosions in grain elevators. Since 1930, 56 grain elevator explosions have been reported. In those explosions 40 people were killed, 145 were injured, and the property losses amounted to more than $7,500,000. These 56 explosions were almost 36 percent of the total number of explosions reported during the period.

It must be recognized, therefore, that the most disastrous losses from dust explosions are occurring in terminal grain elevators, and that satisfactory progress has not been made in the control of dust explosions in this branch of the grain-handling industry. Much of this can be assigned to the lack of provision for adequate dust control during handling, storing, and shipping operations.

In considering this matter several years ago when it was apparent that extensive losses were occurring, the Bureau of Chemistry in the Department of Agriculture learned that many of the dust-collecting systems installed in grain elevators throughout the United States could not be used, or were dismantled because of the objection of the officials having jurisdiction over the weighing of the grain. The weighing departments stated that grain weights were greatly affected by the action of suction used in the collection of the dust. Reports of tests conducted by a number of elevator operators, however, indicated that the weight of the dust removed is almost negligible. Some men experienced in grain handling stated that less dust is removed by suction than is lost in handling grain by means of poor machinery, with no dust-collecting equipment.

Confronted with these conflicting statements, the Bureau of Chemistry made a preliminary study of the effects of dust collection on the weight of grain. The results of this study showed that much depended on the design and installation of the dust-collecting equipment. In many cases the equipment seemed to have been installed with no knowledge of the fundamentals of good design. In some cases the claims of weighing departments that grain had been drawn out by improper application of suction to remove the dust at certain points between the car which was being unloaded and the scales probably were correct. No information concerning a generally accepted method of applying suction or the proper equipment to use could be obtained. Every elevator seemed to have its own system of dust control and no standards existed. None of the systems was so installed as to permit inspection, nor was any of them so designed that it would be impossible to lift grain by increasing the speed of the fan, with a corresponding increase of suction.

It will be necessary to develop and install effective methods for dust control and collection in grain elevators to reduce dust explosion losses. Until this is done it will not be possible to make progress in dust explosion control in terminal grain elevators comparable to what has been accomplished in the control of dust explosions in other grain and milling industries.

EFFECT OF NEW MANUFACTURING PROCESSES

Dust explosions may occur in any industrial plant where combustible dusts are present as the result of the installation of some newly developed equipment. Many of the dust explosions in recent years in the United States have been directly associated with the introduction of new manufacturing processes which have opened up additional sources of ignition, and have resulted in conditions favorable to explosions. It is therefore highly desirable that new manufacturing operations be carefully examined to detect possible dust explosion hazards, and that attention be given to the adoption of preventive measures.

FACTORS IN DUST EXPLOSION PREVENTION

The two principal factors in dust explosion prevention in industrial plants are:

1. Effective measures for control and removal of explosive dust;
2. Elimination and control of sources of ignition.

SOME METHODS FOR PREVENTION AND CONTROL OF DUST EXPLOSIONS

Some of the methods that have proved effective for prevention and control of dust explosions can be listed as follows:

1. Effective Dust Collection and Dust Removal Systems.

Cleanliness and good housekeeping are of prime importance. A dust explosion cannot occur unless combustible dust is present.

2. Removal of Foreign Material from Grain.

Investigations have indicated definitely that dust clouds have been ignited by sparks from metal particles in grain streams.

3. Inert Gas Protection in Grinding and Pulverizing Operations.

The reduction of the oxygen content of the air in enclosed systems by the introduction of an inert gas, such as carbon dioxide (CO_2), in grinding and pulverizing operations has proved effective.

4. Protection of Electrical Appliances and Equipment.

The danger of inadequately protected electrical appliances and equipment has been definitely established.

5. Control of Static Electricity.

Static electricity must be recognized as one of the prominent causes of dust explosions, and provision should be made for the effective removal of static charges from all types of mechanical equipment handling combustible dusts or operating at points where these dusts are present.

6. Closed Storage Bins.

The value of closed storage bins and the undesirability of interconnections between storage bins has been definitely indicated by explosions in grain-handling plants.

7. Explosion Venting Areas in Grain-Handling and Milling Plants.

It is possible to vent grain dust explosions without structural damage, and the effectiveness of glass vents in actual explosions has been well established under actual explosion conditions.

IMPORTANCE OF RESEARCH STUDIES ON DUST EXPLOSION AND FIRE PREVENTION

Research work on dust explosion and fire prevention has as its primary object the development of methods and appliances for the protection of human life, foodstuffs, and property.

The practical application of the research already done has resulted in a marked reduction in losses from dust explosions and fires in some of the principal grain and milling industries. There still remain many important problems in other industries handling and processing agricultural products that must be studied in order to develop further control and prevention methods.